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(54) [Title of Invention] Flexible fiber sheet and its manufacturing method

(57) [Abstract]
[Purpose] The purpose is to provide a flexible sheet with softness, permeability, and recovery from stretching without the shortcomings of the conventional flexible piled fabrics.
[Construction] A flexible fiber sheet is characterized that the sheet is a lamination of polyurethane elastic filament (A) and nonelastic fiber (B) and in the laminated sheet the contacting points of polyurethane filament (A) are fused on to polyurethane filament itself, and the nonelastic fiber (B) is laminated and stretched to above 2-folds of the length of the polyurethane fiber (A) without tension, and its manufacturing method.

[Claim of Patent]

[Claim 1] A flexible fiber sheet is characterized that the sheet is a lamination of polyurethane elastic filament (A) and nonelastic fiber (B) and in the laminated sheet the contacting points of polyurethane filament (A) are fused on to polyurethane filament itself, and the nonelastic fiber (B) is laminated as stretched to above 2-folds of the length of the polyurethane fiber (A) under without tension.
[Claim 2] In the fiber sheet described in Claim 1, the nonelastic fiber (B) is thermoplastic polyester comprising mainly ethylene phthalate repeating unit.
[Claim 3] The manufacturing method of the fiber sheet is characterized that the method comprises a fiber sheet manufacturing process in which thermoplastic fiber forming polyurethane elastomer (a) and thermoplastic fiber forming nonelastic polymer (b) are laminated to composite fiber (C) in lengthwise without being bonded and both exposing to the exterior of the fiber, and the fusion bonding at the contact points of the above polyurethane elastomer (a) in the laminated composite fiber (C); a segmenting process in which the composite filament (C) forming the above sheet is segmented to polyurethane filament (A) and nonelastic fiber (B); and a stretching process in which the sheet is elongated the stretch the above nonelastic fiber (B).
[Claim 4] In the fiber sheet manufacturing method described in Claim 3, a process is added and in additional process a fluid is jetted on the fiber sheet to push the nonelastic fiber (B) into one side of the sheet.
[Claim 5] In the method described in Claim 3, repeated stretching and shrinking of composite filament (C) in benzyl alcohol to achieve the segmenting, where the nonelastic polymer (b) is thermoplastic polyester comprising mainly ethylene terephthalate repeating units.
[Description of Invention]
[0001]
[Industrial Application] This invention pertains to flexible sheet with softness, pleasant touch and permeability, and it's manufacturing method.
[0002]
[Prior Technology] Conventionally, to obtain a piled fabric, various methods were used to direct piling into a flexible cloth. But, in the methods, it was unavoidable that the adhesive for the piling penetrated into the flexible cloth and it's flexibility was greatly deteriorated, and the touch became rough.
[0003] In order to solve the problem, a method was disclosed in Koho Patent Sho50-32338 Koho that the piling process was carried out while bonding of a flexible film on the flexible cloth. But, the infiltration of adhesive into the cloth was unavoidable and the touch became hard and permeability was completely lost.

[0004] Also, in Koho Patent Heil-12659 Koho, it was disclosed that when the flexible film was replaced with a polyurethane elastic nonwoven fabric therenwas improved permeability. However, it was undeniable that the permeability and the softness were deteriorated due to the adhesive in piling process. When the adhesive was used in a small amount to provide softness then the adhesion in piling became insufficient and, problematically, the pile became loose.

[0005]

[Problems to be solved by Invention] In this invention, the conventional problem was solved and the invention provides a flexible fiber sheet with softness, permeability, and excellent recovery from stretching and its manufacturing method.

[0006]

[Means for solving Problems] The invention flexible fiber sheet is characterized that the sheet is a lamination of polyurethane elastic filament (A) and nonelastic fiber (B). The contact points of the above laminated polyurethane filament (A) are fusion bonded on polyurethane filament (A) in the sheet, and the nonelastic fiber (B) is laminated at a length more than twice the length between the contact points of the polyurethane filament (A).

[0007] The fiber sheet manufacturing method is characterized that the method is comprised of thermoplastic fiber forming polyurethane elastomer (a) and thermoplastic fiber forming nonelastic polymer (b). They are laminated to composite fiber (C) lengthwise without being bonded and both exposed to the exterior of the fiber, and then fusion bonded at the contact points of the above polyurethane elastomer (a) in the laminated composite fiber (C); a segmenting process in which the composite filament (C) forming the above sheet is segmented to polyurethane filament (A) and nonelastic fiber (B); and a stretching process in which the sheet is elongated to stretch the above nonelastic fiber (B). And an additional process is added and in the additional process a fluid is jetted on the fiber sheet to push the nonelastic fiber (B) into one side of the sheet.

[0008] The thermoplastic fiber forming polyurethane elastomer used for the composite filament, which forms the invention fiber sheet, is known fusion spinnable polyurethane and there are no special limitations.

[0009] Such polyurethane elastomers are low melting point of polyols with, commonly, molecular weight of 500-6,000. The examples are dihydroxypolyethers, dihydroxypolyesters, dihydropolycarbonate, dihydroxypolyesteramide, etc.; the organic diisocyanate with molecular

weight of less than 500 such as p,p'-dipehnylmethanediisocyanate, tolylenediisocyanate, isophoronediisocynate, hydrogenated diphenylmethanediisocyanate, xyleneddiisocyanate, 2,6-diisocyanate methyl caproate, hexamethylenediisocyanate, etc.; and the chain lengthening agent with molecular weight of less than 500 such as the polymer obtained from the reaction of glycol, amino alcohol, and triol.

[0010] Among the polymers, the acceptable polyols are polytetramethylene glycol, and poly(ε-caprolactone) or polybutylene adipate, which are polyurethanes. Polyethylene glycol was used as a polyol then the hydrophilic property will be enhanced and it can be used for special purposes. For organic diisocyanates, p,p'-diphenylmethanediisocyanate was preferred. For chain lengthening agent, p,p'-bishydroxybenzene and 1,4-butanediol are suitable. A polyurethane elastomer can be synthesized as above-mentioned from a polyol, an organic diisocyanate, and a chain-lengthening agent. But, the suitable one used in the invention contains polyol component of 65 weight percent of total weight, specially preferred one is above 70 weight percent. When the polyol component content was small then the resulting fiber sheet has low elongation and low recovery from stretching.

[0011]For thermoplastic fiber forming nonelastic polymer (b) and nonelastic fiber (B) are the copolymers or their mixtures of polyethylene terephthalate, polybutylene terephthalate, nylon 6, nylon 66, polypropylene. But, the polyethylene terephthalate and ethylene terephthalate unit base (above 80 mole percent) polyester copolymer is preferred considering the photoresistance.

[0012] In the composite filament, which forms the fiber sheet, the above thermoplastic fiber forming polyurethane elastomer (a) and thermoplastic fiber forming nonelastic polymer 9b) can be segmented, as shown in Figs. 1 (i) to (iv), and in all cases it is necessary that it has exposed the portions exposed to the exterior of the filament. Such composite filaments are laminated, and it is beneficial that establishing a fusion bonding between the above polyurethane elastomer (a) at their joints requires more than 30% surface area ratio for polyurethane elastomer (a) in the composite filament. Moreover, the segmentation of nonelastic polymer (b) becomes easy, and to form many thin nonelastic fibers (B), the surface area ratio of 50-75% is preferred.

[0013] The average diameter of the composite filament is commonly less than 70 μm, preferably, 15-50 μm. As the fiber diameter increases the fiber sheet becomes rough. The fiber size of polyurethane elastic filament (A) after segmentation is commonly less than 50 denier. For high stress flexible

pile sheet, the size is set 25-50 denier and for low stress purpose, it was segmented into 2-3 strand and set 1-5 denier for single thread. On the other hand, after the segmentation, the nonelastic fiber (B) has fiber size of less than 30 denier. For high density piling, the segmentation number was increased and for soft piling the single thread size would be 0.1-1 denier. For piling with knot, the fiber size is 5-30 denier; also, their blend can be used. The diameter of the composite filament for the fiber sheet is not the same, and for example, when the average diameter of 20 μm fiber was examined under electron microscope, the diameter is spread between 10 μm to 25 μm range.

[0014] In the invention fiber sheet, the thermoplastic fiber forming polyurethane elastomer (a) and thermoplastic fiber forming nonelastomeric polymer were individually fused and weighed and the joined at the spinning nozzles. For example, as disclosed in Kokai Patent Sho60-99057 and Kokai Patent Hei2-289107, they were spun through spinning nozzles of melt blow spinning apparatus and at the both sides of the nozzle hot gas was blown to refine the composite filament. The refined composite filaments, without being bundled, on the moving conveyor net of the collector were separated by a flow of gas and then laminated on the conveyor net. In the laminated composite, the polyurethane elastomer was fusion bonded by their own retained heat at their contact points of the polyurethane elastomer (a) by their own retained heat in the polyurethane elastomer. On the collector, after the lamination, but before or after the solidification by cooling, it may be bonded by hot pressing by roller. In order to reinforce at the contact points in the composite filament, it may be better to shorten the distance between the spinning nozzle to the collector to laminate and it could be about 1 meter or less than 50 cm.

[0015] In the invention, thermoplastic polyurethane elastomer would be used but to a molten polyurethane elastomer a polyisocyanate compound was admixed and then spun through nozzle to obtain a fiber sheet with improved heat resistance and solvent resistance.

[0016] The fiber sheet in the invention is preferred in that the above composite filament is laminated as open state practically without being bundled. When the single thread is fusion bonded without openness then the softness of the fiber sheet will be lowered and the segmentation of the composite filament will be significantly damaged.

[0017] To segment a portion of the composite filament, which is component for the fiber sheet, there is a combination of polyurethane elastomer (a) and nonelastomeric polymer (b). For example, in the fiber sheet using the combinations having low adhesion, the polyurethane/polyethylene

terephthalate and polyurethane/polypropylene were stretched to elongate the nonelastic fiber (B); for polyurethane/nylon 6 having less segmenting combination, it can be achieved by stretching/shrinking, flexing, twisting, friction etc., which are mechanical means; or a chemical method by immersing in benzyl alcohol or phenol to utilize the difference in the degree of swelling and contraction, or their combination.

[0018] In the method for stretching the nonelastic fiber (B) in the composite filament by stretching the fiber sheet, the fiber sheet was heated by contacting heated fluid, if necessary, or heated by hot rollers to stretch, in one direction, the nonstretched nonelastic fiber (B) between rollers, which may provide a fiber property. If necessary, biaxial stretching can be used which is used for films.

[0019] The stretching ration depends upon the melt blow spin conditions or the applications but, the ratio is set at 70-120% range of the maximum stress (strength) elongation rate (Rmax) in the tensile testing for the measurement of rupture elongation rate (But there are no event exceeding the elongation limit of polyurethane elastic filament (A)). For example, polyethylene terephthalate case it is 3-7 folds, 2.5-6 folds for nylon 6, and 4-12 folds for polypropylene. Because of combining with polyurethane elastic filament, the upper limit is near 6 folds.

[0020] From the segmentation and stretching of the fiber sheet, the nonelastic fiber (B) will be stretched between the joints of polyurethane elastic filament (A) at more than two folds of the filament tension-free state in the lamination and, thus, the nonelastic fiber (B) exist as loosened state, loops, or fuzz. When the elongation rate was set at above 90% of Rmax then a portion of the nonelastic fiber (B) will be severed and there will be a fiber sheet with much fuzz. Also, when the rate was set above 150% then the strength of the fiber sheet may be deteriorated and the retention force of fuzz may decrease.

[0021] An additional process be may added to the invention fiber sheet, a jet flow of air or water may be blown on the fiber sheet to move the nonelastic fiber (B) to one side of the fiber sheet. This process may be very effective after the fiber sheet is elongated at 1.5-2 folds and, this process can further improve the feel of the sheet.

[0022] The fiber sheet manufactured by the invention has rupture elongation of commonly above 300%, preferably, 500-700%. The rupture strength of the fiber sheet may depend upon the thickness of a sheet but it is above 0.5 kg/cm, preferably, above 1.0 kg/cm. Also, the recovery from 100% elongation is commonly, above 80%, preferably above 85%, and it is a sheet

with excellent stretching recovery. The other characteristics of the invention fiber sheet are the extreme permeability and soft touch.
[0023]
[Effects of Invention] By the invention manufacturing process, flexible fiber sheet with various properties described above can be manufactured easily in industrial scale at a low cost. Also, the invention flexible fiber sheet is useful for belt, mask, gloves, fastener at both end of a disposable diaper, protective tape for wounds, etc.
[0024] The invention fiber sheet can be evaluated by following physical properties. Rupture strength and elongation: A 2 cm width specimen was evaluated according to JIS 1096 method at holding distance of 5 cm, and stretching rate of 10 cm/min, and then the strength and elongation per 1 cm were measured at rupture. One hundred percent elongation recovery rate: A 2 cm width specimen was tested at holding distance of 5 cm and stretching rate of 10 cm/min to 100% and then immediately returned to its original length. From the load-elongation curve, the residual elongation rate 1 (%) was determined and 100% elongation recovery rate was calculated by following equation.
[Equation 1]

$$100\%\ \text{Elongation recovery rate}\ (\%) = \{(100 - 1/100)/100\} \times 100$$

Rigidity·softness: JIS L-1096 45° cantilever method.
Permeability: JIS L-1096 method using Flagere (sic) type tester.
Touch and feel: Fabrics were evaluated by skilled persons who have been engaged in handling of fabrics for more than 5 years and ranked by acceptable (O) to unacceptable (×).
[0025]
[Examples]
Comparison 1

A 1160 parts (part signifies weight part hereafter) of polybutylene adipate having dehydrated hydroxyl group value of 56 and 179 parts of 1,4-butanediol were filled in a kneader equipped with jacket and dissolved with stirring and maintained at 85°C, and 660 parts of p,p'-diphenylmethanediisocyanate were added to react. About 30 minutes of continuous stirring, powdery polyurethane was resulted, and this was pelletized by an extrusion apparatus, and then the viscosity at 25°C was measured as 1 g/100 cc solution in dimethyl formamide and it showed that a

thermoplastic polyurethane elastomer having relative viscosity of 2.05 was obtained.

[0026] The resulting polyurethane pellets were spun at melt temperature of 245°C by a melt blow spinning machine having a row of 0.6 mm diameter spinning nozzles with hot gas jetting slits for air at 200°C and 1.8 kg/cm^2 on both sides of each nozzle to refine the fiber. The refined filaments were collected on a 30 mesh metal net conveyor 25 cm below the nozzles and the collected fibers were rolled by rollers to nonwoven fabric of 60 g/cm^2 weight.

[0027] The resulting nonwoven fabric was a lamination of average diameter 20 μm monofilament of polyurethane elastic fiber in an open state and the joints of the filaments were bonded each other.

[0028] The Comparison 1 thermoplastic polyurethane elastomer was melted at 245°C, and polyethylene terephthalate (readily dyeing polyester) copolymerized with 5% polyethylene glycol of molecular weight 600 was melted at 285°C, and these two were joined to the configuration similar to Fig. 1 (i) at 2:1 weight ratio, and then spun. Then fiber sheet comprising composite filament of average diameter of 24 μm was obtained by Comparison 1 procedure. The resulting fiber sheet was laminated with single threads of composite filament in an open state and the joints of the composite filaments were bonded by polyurethane elastomer component.

[0029] Subsequently, the fiber sheet was elongated to 3.0 folds in hot water by rolling rollers and at the same time the stretching and shrinking process was repeated by a stainless steel plate moving up and down twice every second (3.0-4.0 fold elongation) to segment the composite filament, which is the component of the fiber sheet. The segmented polyurethane elastomer filament was average 4 denier fiber size and the segmented and stretched readily dyeing polyester fiber had average 0.8 denier fiber size. The readily dyeing polyester fiber laminated as loose and loops shaped fibers.

[0030] Example 2

A fiber sheet was manufactured according to Example 1 procedure with exception of starting from the shape shown in Fig. (ii). The readily dyeing polyester fiber had average fiber size of 0.4 denier.

[0031] Example 3

The elongation by rolling roller was set to 4.0 folds and the stretching and shrinking ratio by stainless steel plate was set to 4.0-5.0 folds and then processed according to Example 2 procedure to manufacture fiber sheet. In the resulting fiber sheet, a portion of the readily dyeing polyester fibers was fuzzy and had peach skin touch.

[0032] Comparison 2

An emulsion type acrylic adhesive (Yodosol A-4540) and foaming controlling agent (Kanevinol YC80) were mixed and stirred to foam in a hopper until the volume increase 1.5 folds to obtain an adhesive. The adhesive was coated on the polyurethane nonwoven fabric obtained in Comparison 1 using a wire doctor and then fiber length 0.8 mm and fiber size 1.5 denier brown rayon was piled by electrostatically to obtain a cloth.

[0033] Example 4

The fiber sheet obtained in Example 3 was stretched 1.5 folds and water was jetted through a nozzle diameter of 0.25 mm under water jet pressure of 30 kg/cm^2 to move on one side of the readily dyeing polyester fibers. The resulting fiber sheet was dyed with a dispersion dye and the resulting one layer lamination has peach skin touch.

[0034]

[Table 1]

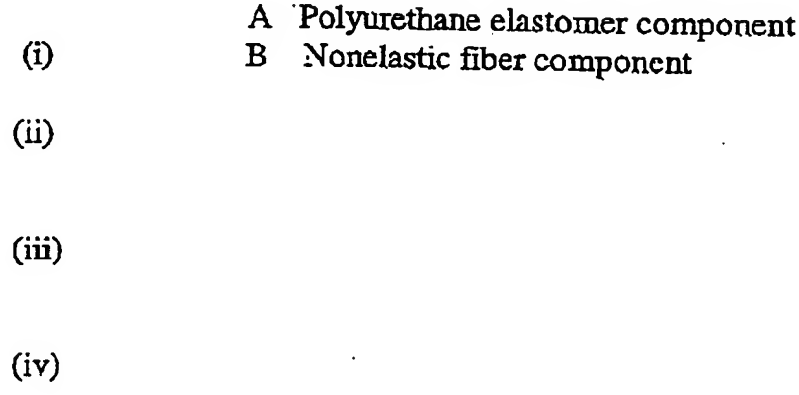
Comparative evaluations of various fiber sheets

Test No.	Ex. 1	Ex. 2	Ex. 3	Comp. 1	Comp. 2
Weight, g/cm^2	60	60	60	60	300
Configuration	Fig. 1 (i)	Fig. 1 (ii)	Fig. 1 (ii)	-	-
100% Elongation recovery rate, %	90	87	86	92	45
Rigidity-softness, mm	29	27	27	26	57
Permeability, mL/cm^2/sec	450	410	440	480	80
touch-feel	Δ	O	O peach skin	×	O velvety

[Description of Figures]

[Fig. 1] The cross sectional views of the composite filaments suitable for the invention are given.

[Fig. 1]



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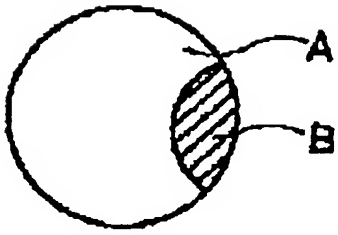

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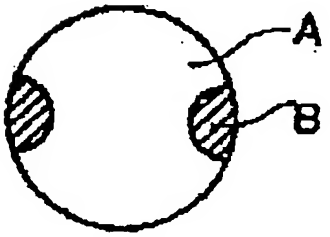

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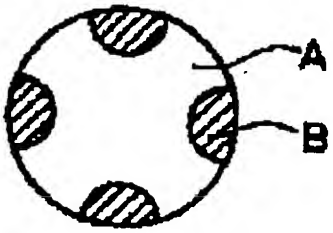

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